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(54) Abstract Title
Thermal processing apparatus

(57) Thermal processing apparatus for a sheet-like workpiece W such as a semiconductor wafer, optical disc or liquid crystal substrate, comprises a heat transfer plate 2 under which an electric heater 3 is installed to heat the heat transfer plate evenly. Peltier elements 5 are additionally provided under the electric heater, and may be used to raise or lower the temperature of the workpiece, there being a cooling section 6 through which cooling liquid flows. There may be an intermediate plate 4 to diffuse heat from the Peltier elements 5. A controller 9 controls the ac power to the electric heater 3 and dc direction and power to the Peltier elements 5 in dependence on the output of a temperature sensor 8.

FIG.1

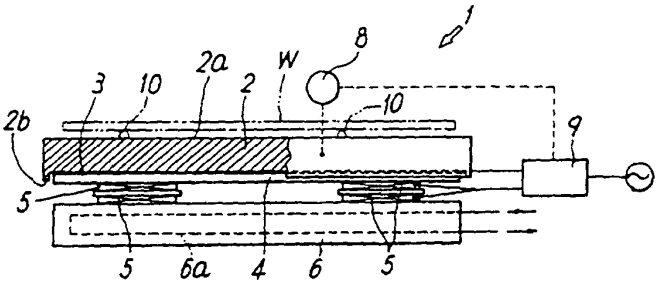

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FIG.1

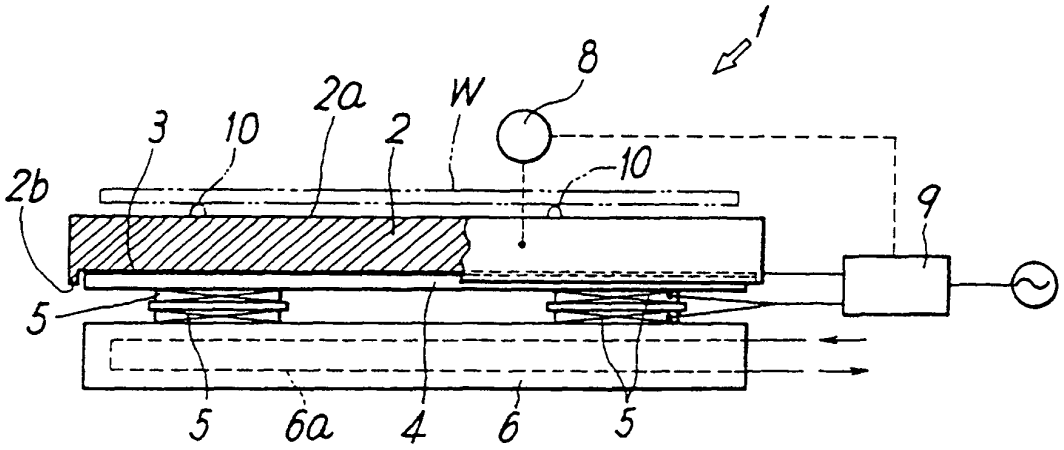


FIG.2

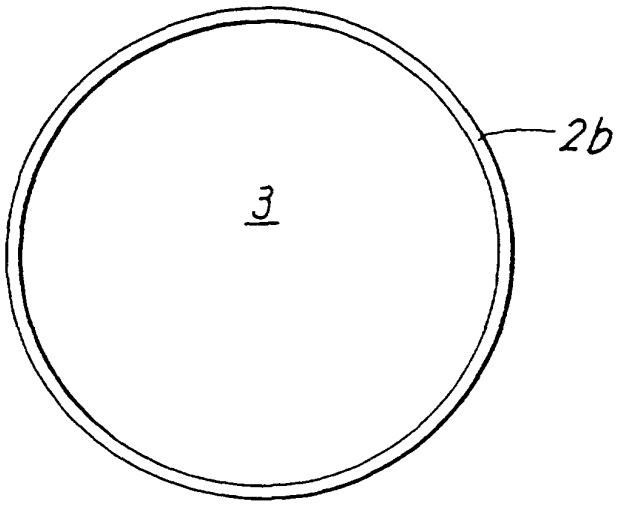


FIG.3

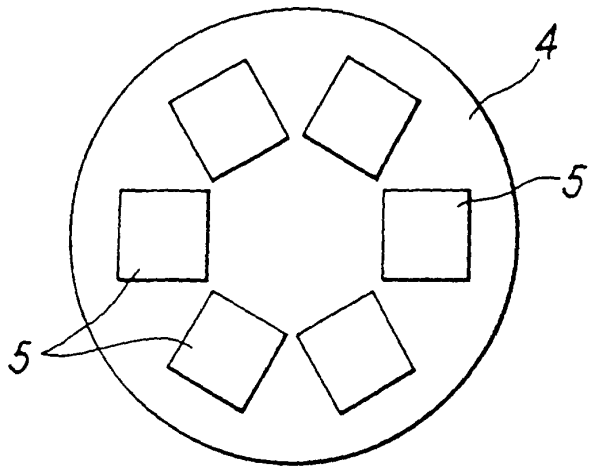
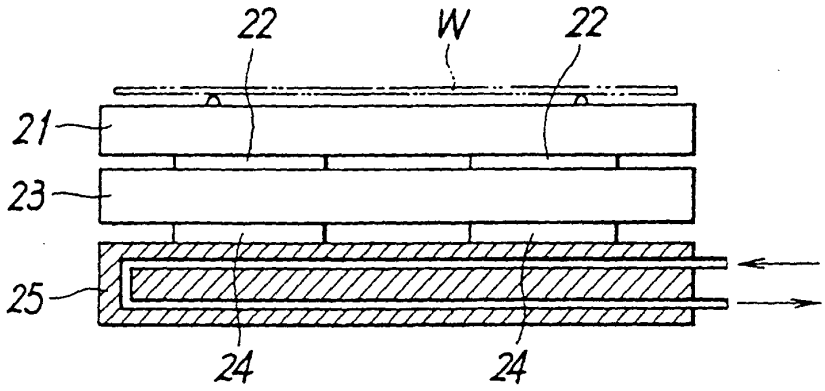


FIG.4



THERMAL PROCESSING APPARATUS FOR SHEET-LIKE WORKPIECES

The present invention relates to a thermal processing apparatus for sheet-like workpieces such as semiconductor wafers, or optical disc or liquid crystal substrates.

Japanese Patent Application No. 9-140492 describes a thermal processing apparatus for sheet-like workpieces that employs Peltier elements.

As shown in FIG. 4, the known thermal processing apparatus comprises multiple supplementary heating Peltier elements 22; a main heating means 23 which has a built-in electric heater, and a cooling means 25 located via heat-exchanging Peltier elements 24 installed under a heat transfer plate 21.

A workpiece W is placed on the heat transfer plate 21 with a small gap therebetween. Heat from the main heating means 23 is transmitted to the heat transfer plate 21 via the Peltier elements 22, and radiant

heat from the upper surface of the heat transfer plate 21 is used to heat the workpiece W to a predetermined temperature. To cool the workpiece W, heat from the heat transfer plate 21 is transferred from the Peltier elements 22 to the cooling means 25 via the main heating means 23 and heat-exchanging Peltier elements 24.

Thermal treatment apparatuses using Peltier elements have the advantage of providing excellent processing efficiency as a result of prompt heat transferral during heating and cooling. If, however, the multiple Peltier elements are assembled on the heat transfer plate 21, then due to restrictions imposed by the shape and size of the Peltier elements 22 and practical problems, it is difficult to install the Peltier elements without leaving gaps between them. As a result of such gaps, the temperature distribution of the heat transfer plate 21 cannot be made completely uniformly, due to the likelihood of a slight difference in temperature between those portions which are adjacent the Peltier elements 22 and those which are not. In normal heating, such a difference in temperature does not create a significant problem. In the case of workpieces for which precise heating is required, however, it is desirable that the difference in temperature be eliminated in order to make the temperature distribution as uniform as possible.

It is an object of this invention to provide a thermal processing apparatus having a high heating accuracy, which can reliably homogenize the temperature distribution of a heat transfer plate used for the thermal processing of workpieces by a simple mechanism.

It is another object of this invention to enable the temperature of the heat transfer plate of a thermal processing apparatus to be increased and decreased promptly in order to improve the efficiency of heating and cooling workpieces.

To achieve these objects, this invention provides a thermal processing apparatus comprising multiple Peltier elements and a cooling section assembled via an electric heater under a heat transfer plate, the top surface of which is a heat transfer surface that transfers heat to workpieces. The electric heater is installed in such away as to evenly heat the heat transfer surface of the heat transfer plate.

In a thermal processing apparatus of this configuration, when the electric heater is interposed between the multiple Peltier elements and the heat transfer plate, the Peltier elements and the electric heater are used to heat

the heat transfer plate. Thus, the electric heater can be used to correct the difference in temperature between those portions of the heat transfer plate adjacent which the Peltier elements are present and those from which the Peltier elements are absent, thereby approximately homogenizing the temperature distribution of the heat transfer surface of the heat transfer plate. Furthermore, the amount of power supplied to the Peltier elements can be increased and reduced in order to simply adjust the temperature of the heat transfer plate. Consequently, the temperature of the heat transfer plate can be set and adjusted easily.

In addition, to cool workpieces, the electric heater is turned off and a reverse direct current is allowed to flow through the Peltier elements to use the heat-transfer-plate side of the Peltier elements as the cooled side. Heat from the heat transfer plate is transferred to the cooling section through the Peltier elements in order to reduce the temperature of the heat transfer plate promptly.

Thus, if the temperature of the workpieces is higher than the set temperature of the heat transfer plate or if the heat transfer plate is to be used to cool the workpiece, the power to the electric heater is turned off and the current through the multiple Peltier elements is reversed to cool the heat transfer plate by means of the Peltier elements. As a result, the temperature of the heat

transfer te can be reduced prompt[redacted].

In addition, since the heat in the heated side of the Peltier elements is released, the cooling efficiency of the Peltier elements increases.

According to one embodiment, the electric heater is manufactured in the form of a sheet by enclosing a heating element in a casing that resists and transfers heat and that provides electric insulation, and the heater is of a size corresponding to the overall heat transfer surface of the heat transfer plate.

According to another embodiment, an intermediate plate consisting of a material that transfers heat is installed between the electric heater and the Peltier elements in such a way as to cover the entire electric heater. The intermediate plate acts as both a means for pressing and holding the electric heater and a means for diffusing heat from the multiple Peltier elements in order to transfer it uniformly to the entire heat transfer plate. The intermediate plate enables the temperature distribution of the heat transfer plate to be more reliably homogenized.

Furthermore, multiple Peltier elements may be stacked one atop the other.

According to a specific embodiment, the thermal processing apparatus comprises a temperature

sensor for detecting the temperature of the heat transfer plate and outputting a signal; and a controller that controls the power to the electric heater and the Peltier elements in response to the output signal from the temperature sensor.

The invention will now be further described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a sectional view showing one embodiment of a thermal processing apparatus according to this invention.

FIG. 2 is a rear view showing an electric heater mounted on a heat transfer plate.

FIG. 3 is a top view showing an arrangement of Peltier elements.

FIG. 4 is a sectional view of a proposed thermal processing apparatus.

FIG. 1 shows a representative embodiment of a thermal processing apparatus according to this invention. A thermal processing apparatus 1 has a heat transfer plate 2 the top surface of which is a heat transfer surface 2a along which heat is transferred to a sheet-like workpiece W; an electric heater 3 installed under the heat transfer plate 2 to evenly heat the overall heat transfer surface 2a; an intermediate plate 4 provided under the electric heater 3;

multiple Peltier elements 5 installed adjacent to one another in such a way as to heat the heat transfer plate 2 via the intermediate plate 4 and electric heater 3; and a cooling section 6 installed under the Peltier elements 5.

A workpiece W is placed on the heat transfer plate 2, which heats and/or cools it to a predetermined temperature. The heat transfer plate is formed as a disk having a larger diameter (for example, 200 to 320 mm) than the workpiece W, and an annular edge 2b is formed on the outer circumference of the bottom surface of the plate 2 in such away as to surround the electric heater 3 as shown in FIG. 2. The inner diameter of the edge 2b is slightly larger than the outer diameter of the workpiece W.

The electric heater 3 is formed as a thin sheet having a size corresponding to the overall heat transfer surface 2a of the heat transfer plate 2, by enclosing a heating element in a casing that resists and transfers heat and that provides electric insulation. The heating element is formed by cutting a thin foil material, which generates heat due to electric resistance, into a predetermined pattern or folding a linear material into a predetermined pattern. The casing is formed of silicone rubber.

In addition, the intermediate plate 4 acts as both a means for holding the electric heater 3 and a means for diffusing heat from the multiple Peltier elements 5 to

transfer it uniformly to the entire heat transfer plate 2. The intermediate plate is preferably formed of a material such as aluminum or copper that transfers heat appropriately and is installed in such a way as to cover the entire electric heater 3. The intermediate plate 4 preferably has a thickness of, for example, 5 mm.

The Peltier elements 5 are arranged radially around the center of the heat transfer plate 2 at equal angles and equal intervals as shown in FIG. 3. In addition, the Peltier elements 5 are preferably installed in such a way that two elements are stacked as shown in the figure in order to maintain a difference in temperature between the two vertical surfaces.

The cooling section 6 includes a cooling channel 6a through which a cooling liquid flows and which is connected to a cooling water source.

The thermal processing apparatus 1 also includes a temperature sensor 8 that detects the temperature of the heat transfer plate 2 in order to output a signal; and a controller 9. The controller 9 controls the amount of power supplied to the electric heater 3 and each Peltier element 5 in response to the output signal from the temperature sensor 8 in order to adjust the temperature of the heat transfer plate 2. An alternating current is supplied to the electric heater 3, and a direct current is

supplied the Peltier elements 5. e direct current supplied to the Peltier elements 5 can be reversed.

The heat transfer plate 2 has three equilateral-triangular spacers 10 that support the thermally processed workpiece W with a slight gap between the plate 2 and the heat transfer surface 2a and that each have a spherical tip. An appropriate elevating means (not shown) can be used to elevate these spacers 10 from the illustrated positions to the respective positions at which they protrude.

These spacers 10 allow a slight gap to be maintained between the top surface of the heat transfer plate 2 and the workpiece W. Although the amount of heat transmitted to the workpiece W slightly decreases as result, this gap enables the workpiece W to be heated and cooled more uniformly.

In the thermal processing apparatus of this configuration, to heat the workpiece W, a direct current is allowed to flow through the Peltier elements 5 in a direction such that the heat transfer plate 2 is the heated side, while an alternating current is allowed to flow through the electric heater 3. Thus, the heat transfer plate 2 is heated by the electric heater 3 and the Peltier elements 5 in order to uniformly heat the workpiece W on the heat transfer surface 2a. In this case, a cooling liquid is allowed to flow through the cooling channel 6a in the cooling section 6.

In response to a signal output from the temperature sensor 8, the temperature of the heat transfer plate 2 is precisely controlled by adjusting the amount of power supplied to the electric heater 3 and the Peltier elements 5 by means of the controller 9.

Thus, the electric heater 3 is installed closer to the heat transfer plate 2 than the Peltier elements 5, and the Peltier elements 5 are provided outside the electric heater 3. Therefore, the electric heater 3 directly heats the heat transfer plate 2 to prevent the temperature of the heat transfer plate 2 from varying between those portions in which the Peltier elements 5 are present and those from which the elements 5 are absent, thereby enabling the temperature distribution of the overall heat transfer surface 2a of the heat transfer plate 2 to be reliably homogenized. Moreover, the heat from the multiple Peltier elements 5 is diffused by the intermediate plate 4 and transmitted to the entire heat transfer plate 2, thereby further facilitating the homogenization of the temperature distribution of the heat transfer plate 2.

In addition, the amount of power supplied to the Peltier elements 5 can be increased and reduced in order to simply adjust the temperature of the heat transfer plate 2. Consequently, the temperature of the heat transfer plate 2 can be set and adjusted easily.

To [redacted]uce the temperature of th[redacted]orkpiece W, a reverse current can be allowed to flow through the Peltier elements 5. This means that the heat-transfer-plate (2) side of the Peltier elements 5 is the cooled side. The temperature of the heat transfer plate 2 can therefore be reduced.

In addition, to cool the heated workpiece W, the electric heater 3 is turned off and a reverse direct current is allowed to flow through the Peltier elements 5 as described above. Thus, the heat-transfer-plate (2) side of the Peltier elements 5 is used as the cooled side to transfer the heat from the heat transfer plate 2 through the Peltier elements 5 in order to reduce the temperature of the heat transfer plate 2 promptly.

If the temperature of the workpiece W is higher than the set temperature of the heat transfer plate 2 or if the heat transfer plate 2 is used to cool the workpiece W, the power to the electric heater 3 is turned off and the current is allowed to flow in reverse through the multiple Peltier elements 5.

In addition, since the heat in the heated side of the Peltier elements 5 is released by the cooling section 6, the cooling efficiency of the Peltier elements 5 increases.

CLAIMS

1. A thermal processing apparatus comprising a heat transfer plate, at least part of the top surface of which is a heat transfer surface from which heat is transferred to a sheet-like workpiece, an electric heater installed under the heat transfer plate to evenly heat the heat transfer surface, multiple Peltier elements installed adjacent to one another in such a way as to heat the heat transfer plate via the electric heater, and a cooling section installed under the heater.

2. A thermal processing apparatus as claimed in Claim 1 wherein the electric heater is in the form of a sheet of a size corresponding to that of the heat transfer surface of the heat transfer plate, the heater comprising a heating element enclosed in a casing of heat conductive and electrically insulative material.

3. A thermal processing apparatus as claimed in either Claim 1 or Claim 2 wherein an intermediate plate of a heat transfer material is installed between the electric heater and the Peltier elements, the intermediate plate covering the entire electric heater, the intermediate plate acting as both a means for holding the electric heater and a means for diffusing heat from the multiple Peltier elements to transfer it uniformly to the heat transfer plate.

4. A thermal processing apparatusas claimed in any preceding Claim wherein the multiple Peltier elements are arranged in stacks.

5. A thermal processing apparatus as claimed in any preceding Claim further comprising a temperature sensor for detecting the temperature of the heat transfer plate and outputting a signal, and a controller that controls the power to the electric heater and the Peltier elements in response to the output signal from the temperature sensor.

6. A thermal processing apparatus substantially as hereinbefore described and illustrated in the accompanying drawings.

The Patent Office

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Application No: GB 9820636.0 **Examiner:** Martyn Dixon
Claims searched: all **Date of search:** 13 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1K (KLHX,KLXD,KTC,KTQ); H5H (HNX)

Int Cl (Ed.6): H01L (21/00,23/34,23/38,35/28,35/30,35/32); H05B (11/00); F25B (21/02,21/04)

Other: Online: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A,E	GB 2326278 A	(SMC)	1
X	GB 2261111 A	(Stuart Scientific) see fig 1	1
X,P	WO 98/05060 A	(Stanford Junior University) see fig 4B, page 9, lines 4-7, page 10, lines 7-9, page 13, lines 19-20 and page 14, lines 6-7	1,5
A,P	JP 090306978 A	(Dainippon Screen) see abstracts	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.